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SPECIAL REPORT NO. 7

P-3C DEPOT SUPPORT STUDY

July 1970

Prepared for
NAVAL AIR SYSTEMS COMMAND
DEPARTMENT OF THE NAVY
WASHINGTON, D. C.
under Contract N00019-70-C-0027

ARINC RESEARCH CORPORATION

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ABSTRACT

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The depot support requirements for the avionic systems peculiar to the P-3C aircraft were evaluated to assist the Naval Air Systems Command in selecting an effective method of supporting the P-3C avionics. Two depot-support concepts were investigated, and a cost comparison of the concepts was performed for selected systems. The following two support concepts were compared:

- Use of Peculiar Ground Support Equipment (PGSE)
- Use of Automatic Test Systems (ATS)

The ATS was found applicable to most of the 30 avionic systems peculiar CONT

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By
C. F. Wells

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Prepared under Contract N00019-70-C-0027
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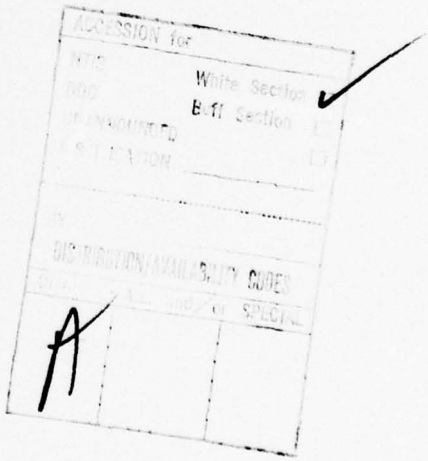
ABSTRACT

The depot support requirements for the avionic systems peculiar to the P-3C aircraft were evaluated to assist the Naval Air Systems Command in selecting an effective method of supporting the P-3C avionics. Two depot-support concepts were investigated, and a cost comparison of the concepts was performed for selected systems. The following two support concepts were compared:

- Use of Peculiar Ground Support Equipment (PGSE)
- Use of Automatic Test Systems (ATS)

The ATS was found applicable to most of the 30 avionic systems peculiar to the P-3C, and it was determined that ATS support could provide significant savings in cost and in requirements for space, personnel, and training. ATS support was recommended for 17 of the 30 P-3C avionic systems considered, and PGSE is recommended for the remaining systems.



SUMMARY

This study was conducted by ARINC Research Corporation to assist the Naval Air Systems Command in selecting depot-support equipment for the avionic systems peculiar to the P-3C aircraft.

The maintainability design objective of the P-3C is on-board fault isolation to the defective module, replacement of modules at the organizational level, and a minimum of Intermediate Maintenance Activity (IMA) support. Under this maintenance concept, modules replaced at the organizational level are sent directly to the depot for test and repair, thus necessitating the test and repair of a large number of individual modules. This demand for module test and repair can be satisfied with an assemblage of Peculiar Ground Support Equipment (PGSE) or by use of an Automatic Test System (ATS) capable of supporting a wide range of module types.

The study reported here consisted of analyzing and comparing two types of depot support (PGSE and ATS) for the avionic systems peculiar to the P-3C. The ATS currently installed and in use at Naval Air Rework Facilities (NARFs) within the continental United States was used for this comparison.

PGSE is normally designed to support a specific equipment and is assumed to be compatible with that equipment in all respects. An ATS, on the other hand, may not be totally compatible with a given system. P-3C systems were therefore screened to determine whether they were amenable to ATS support and the modules of six avionic systems were evaluated to establish the extent to which they are compatible with the ATS being used at the NARFs. This evaluation consisted of analyzing the module characteristics and test specifications detailed in the applicable engineering data package and comparing those data with the stimuli and measurement characteristics of ATS being used at the NARFs.

This evaluation revealed that 92 percent of the modules in the six P-3C systems could be supported by the ATS as it is currently configured. Alternate support methods which could provide support for the remaining modules were also investigated. The following are some of the methods considered for alternate support:

- Vendor repair for an indefinite period
- Specially configured NARF test equipment
- Module throwaway
- ATS building blocks
- PGSE and modified PGSE

Preliminary investigations revealed that an additional six percent of the modules considered for the six systems could be tested by adding Synchro and High-Voltage building blocks to the current ATS.

A comparison of the combined hardware and software costs for two depot-support methods was conducted for six avionic systems peculiar to the P-3C. The initial overall savings to be realized by using the ATS support concept for these six systems amounts to $729,769. Considerable additional savings can be realized as the result of the reduction in space, training, and manpower requirements that will accrue from use of the ATS.

ARINC Research recommends that the following guidelines be used in supporting the selected P-3C avionic systems.

Number of Systems	Type of Support
15	ATS
2	ATS and PGSE Combined
13	PGSE

It is also recommended that a Multiplex Test Station, equipped with the High-Voltage and Synchro building blocks, be purchased for each Designated Overhaul Point (DOP) to support selected P-3C systems and that the Navy depot capabilities be established at the earliest possible date.

It will be necessary to purchase engineering data packages, overhaul manuals, or both for avionic systems in the P-3C (primarily CFE systems for which these data are not already available).

CONTENTS

CONTENTS (continued)

Table 1. **AVIONIC SYSTEMS PECULIAR TO THE P-3C AIRCRAFT**

System	Organizational Repair Level		IMA Support	Module Population	Number of Module Types	Engineering Data Package Available	Amenable to ATS Support (either partially or totally)	Not Amenable to ATS Support
	Module	Assembly						
AM-4923A (CFE)	X		No	42	5	No	X	
AN/ACQ-5 (CFE)	X		No	200	161	No	X	
AN/AGC-6 (CFE)	X		No	36	29	No	X	
AN/AJN-15 (CFE)	X		No	9	9	No	X	
AN/ARR-72 (CFE)	X	X	Yes[1]	176	25	No	X	
AN/ASA-69 (GFE)	X		No	50	45	Yes	X	
AN/ASA-70 (GFE)	X		No	105	35	Yes	X	
AN/ASQ-114 (GFE)	X		No	502	82	Yes	X	
AN/AYA-8 (GFE)	X		No	576	88	Yes[2]	X	
CV-2461/A (GFE)	X		No	78	40	Yes[3]	X	
ID-1540 (CFE)		X	No	15	5	No		X
TD-900/AS (CFE)	X		No	5	5	No	X	
AN/AQA-7 (GFE)	X	X	Yes	204	68	No	X	
AN/ASN-84 (CFE)	X	X	Yes	86	41	No	X	
AN/APS-115 (CFE)	X	X	Yes	67	46	No	X	
AN/APN-187 (CFE)	X	X	Yes	28	28	No	X	
AN/ARC-142 (CFE)	X	X	Yes	120	60	No	X	
AN/ARC-143 (CFE)	X	X	Yes	42	21	No	X	
AN/ASA-64 (GFE)	X		Yes	5	5	Yes	X	
AN/ASA-65 (GFE)	X		Yes	8	4	Yes	X	
AN/ASA-66 (GFE)	X		Yes	10	10	Yes	X	
AN/AXR-13 (GFE)	X	X	Yes	18	18	Yes[4]	X	
RO-308/SSQ-36 (GFE)	X		Yes	2	2	Yes	X	
51V4 (CFE)		X	Yes	5	5	No		X
AN/ALQ-78 (CFE)	X	X	No	186	72	No	X	
AN/AQH-4 (CFE)	X		Yes	20	5	No	X	
AN/ARA-50 (GFE)		X	Yes			No		X
AN/ASQ-81 (GFE)	X	X	No	15	15	No	X	
AN/ASW-31 (CFE)	X	X	No	138	34	No	X	
R-1651 (CFE)		X	Yes			No		X

[1] ASSG only
[2] Did not include RD-319 (MTT)
[3] No test specifications — could not evaluate
[4] Limited in depth — could not evaluate

obstacles would be encountered in meeting the desired Turn-Around-Time (TAT) as a result of a combination of problems, such as the following:

- Insufficient personnel
- Insufficient facilities
- Insufficient support equipment
- Difficulty in obtaining spare parts

These problems make it desirable to develop Navy depot capability as soon as possible.

1.1.3 Task Assignment

Under Contract N00019-70-C-0027 with the Naval Air Systems Command, ARINC Research Corporation was assigned the task of investigating depot facilities requirements and making recommendations to assist NASC in selecting depot support equipment for the P-3C.

As a result of a previous study* by ARINC Research Corporation, it was concluded that the ATS currently installed and in use at NARFs in the continental United States had characteristics that were applicable to P-3C depot support and, in its present configuration, the ATS could be used to test approximately 80 percent of the 71 module types investigated on selected avionic systems in the P-3C.

At a number of meetings at which depot-support equipment was the subject of discussion, the ATS in use at the NARFs was considered as a candidate for testing modules of selected P-3C avionic systems. ARINC Research Corporation compared module characteristics and test specifications of selected Government Furnished Equipments (GFE) with the stimuli and measurement capabilities of the ATS and made recommendations for depot-support equipment based on these evaluations. A tentative Component Pilot Rework (CPR) listing based on ARINC Research recommendations, was formulated at the P-3C Transition Planning Conference of 19 - 21 January 1970. The recommended support equipment includes both the ATS in use at the NARFs and Peculiar Ground Support Equipment (PGSE).

1.2 APPROACH

The problem of selecting test equipment for support of the many different systems must be resolved to prevent unnecessary delays in developing Navy depot capability.

To provide information that will be helpful in making a decision to select depot-support equipment from among several alternatives, certain steps must be taken. Figures 1 and 2 are flow charts depicting the approach used in evaluating alternate support equipments.

Basically, the comparison was between PGSE support and ATS support. PGSE includes special module testers, Test Bench Installations (TBIs), or any equipment designed to support a particular equipment or system. An ATS is considered standard support equipment since it has applications to more than a single end item or end article.

*ARINC Research Special Report No. 5, *Preliminary Report on the Investigation of a Universal P.C. Card Tester to Support the P-3C A-NEW Avionics Equipment*, July 1969.

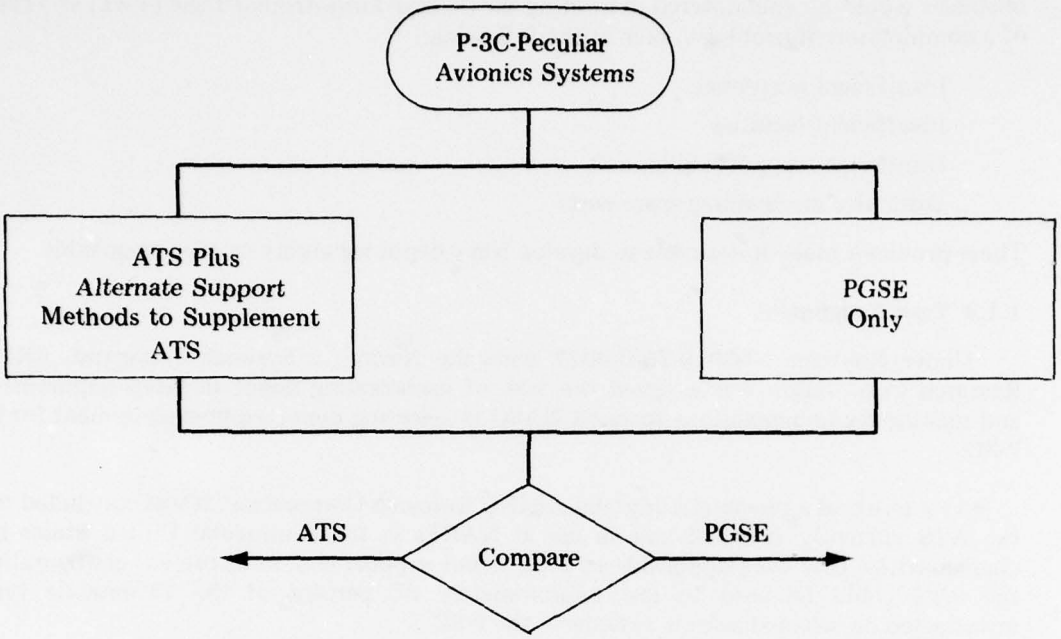


Figure 1. **PRELIMINARY APPROACH TO EVALUATING DEPOT-SUPPORT EQUIPMENT FOR P-3C AVIONICS**

The task of investigating the requirements of depot facilities and providing recommendations to the Naval Air Systems Command (NASC) consisted of the following steps:

- Screening of avionic systems peculiar to the P-3C to establish their amenability to ATS support
- Determination of the degree of compatibility between the ATS at the NARFs and the modules in P-3C avionic systems. This evaluation was conducted using test requirements developed from the available subsystem engineering data package*
- Selection of modules for pilot programming and testing to demonstrate the ability of the ATS to successfully support P-3C modules
- Investigation of alternate support methods for modules that are not compatible with the ATS in use at the NARFs
- Comparison of investment costs and other pertinent requirements of PGSE and ATS
- Submittal of recommendations to NASC

The remaining P-3C avionic systems, for which there are insufficient data packages on which to base a comparison, were evaluated to determine the best method of depot support. This evaluation was based upon engineering judgment, available maintenance data, a comparison of similar types of systems, and other related data.

*Complete engineering data packages were available for six GFE systems at the time of this evaluation.

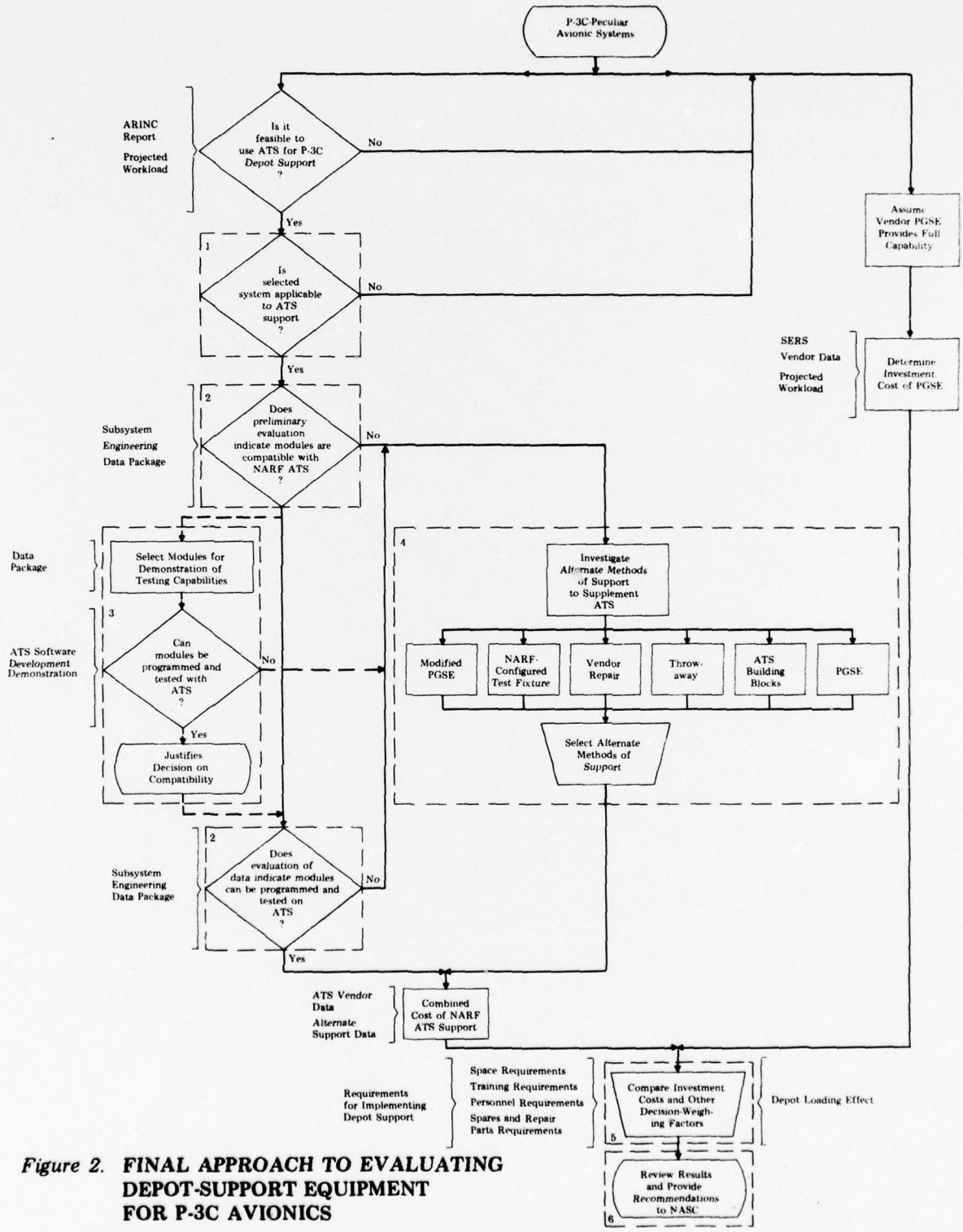


Figure 2. **FINAL APPROACH TO EVALUATING DEPOT-SUPPORT EQUIPMENT FOR P-3C AVIONICS**

CHAPTER TWO

SCREENING OF AVIONIC SYSTEMS IN THE P-3C

As indicated in Figure 2, the first step in investigating the requirements for depot facilities was to determine the applicability of the ATS to the support of specific systems. Some of the factors considered in this analysis were the following:

- The systems-maintenance concept of the P-3C
- The necessity to deviate from the maintenance concept

Table 1 lists the results of this screening under the headings "Amenable to ATS Support" or "Not Amenable to ATS Support."

P-3C systems for which only "black box" replacement at the organizational level is allowable were identified in Table 1 as "Not Amenable to ATS Support", since the primary function of the ATS is module testing.

For some systems, replacement of both modules and assemblies at the organizational level is acceptable. The modules that fall into this category lend themselves to ATS support at the depot level. The assemblies, on the other hand, often comprise removable modules and hard-wired circuits. It is conceivable that modules of these assemblies could be tested on the ATS, but in many cases this would not be feasible since PGSE would also be required to test the complete assembly. These systems, to which the ATS has only limited applicability, are therefore listed under the heading "amenable to ATS support" in Table 1.

2.1 P-3C SYSTEMS MAINTENANCE CONCEPT

The maintenance philosophy of the P-3C avionics systems discussed in Section 1.1.1, was directed towards module replacement at the organizational level and repair of these modules at the depot level. It appears feasible that selected systems can be maintained without the support of an IMA, providing certain design goals are achieved. Some of these goals are listed below:

- Systems designed for on-board module replacement without removal of assemblies
- Incorporation of BITE and diagnostic test routines in new systems and use of other on-board aids to provide rapid fault isolation to the module level
- High reliability
- No alignment required after module replacement

These goals have been achieved for some of the avionic systems of the P-3C.

2.2 DEVIATION FROM MAINTENANCE CONCEPT

Although the maintenance concept of the P-3C systems is oriented toward module replacement at the organizational level, it is sometimes necessary to deviate from this concept and replace an assembly rather than a module. A few reasons for such deviations are cited below:

- Circuit design or equipment construction prevents module replacement
- Built In Test Equipment (BITE) is incapable of isolating faults to the defective module
- Multiple failures
- It may be necessary to bring an aircraft to an "up" status in the shortest possible time

The depot-repair capability must be flexible enough and up to date enough to cope with the types of repairs and workloads anticipated. Appendix A contains a projection of depot workloads.

CHAPTER THREE

COMPATABILITY OF ATS AND MODULES OF P-3C AVIONIC SYSTEMS

The large number of module types in the P-3C equipment and the maintenance support required, emphasizes the advantages of using an ATS at the depot level for test and repair of P-3C avionic modules.

The evaluation of modules in the P-3C avionic systems for compatability with the ATS was confined to plug-in type printed circuit boards containing discrete components or integrated circuits (flat packs), or both, with a connector of ordered array pins. Although repairable modules are of prime interest, various consumable (coded) modules and modules previously designated for vendor repair were also considered in the evaluations. A functional test should be developed to determine whether the module is actually defective before it is discarded. It must be determined whether the stimuli and measurement capabilities of an ATS exist for the many module types in the P-3C equipments and if the ATS is capable of being programmed to isolate failures to components or integrated circuits. To make this determination, the ATS currently in use at the NARFs was evaluated to determine its capability to test the selected modules. Test requirements developed from the subsystem engineering data packages were used for the evaluation.

3.1 ENGINEERING DATA PACKAGE

Considerable effort has been expended in obtaining and analyzing P-3C module data. GFE engineering data packages for the AN/ASA-64, AN/ASA-65, AN/ASA-66, AN/ASA-69, AN/ASA-70, and AN/ASQ-114 were obtained from Naval Air Technical Services Facility (NATSF). An analysis was conducted to determine compatibility of these equipments and the ATS. Complete data packages contain the following items:

- Acceptance/operational test specifications for the modules
- Module alignment procedures
- Schematic diagrams of the modules
- Physical descriptions, parts lists, and layouts of the modules
- Information on theory of operation of the modules

Because incomplete engineering data packages were available for the following GFE systems, only a limited analysis of them could be conducted:

- AN/AYA-8 (did not include RD-319, Magnetic Tape Transport (MTT)
- CV-2461/A
- AN/AXR-13

} Limited in depth

3.2 METHOD OF EVALUATION

The method of evaluating P-3C avionics modules for compatibility with the NARF ATS consisted of the following:

- Analyzing the module characteristics and test specifications as detailed in the available subsystems engineering data packages
- Comparing the stimuli and measurement characteristics of the ATS and the modules

Test specifications sometimes include the characteristics of recommended PGSE. These additional data were further used to substantiate module compatibility with the ATS.

To verify the test compatibility of the modules and the ATS, two sample modules were programmed and tested.

3.3 SELECTIONS OF MODULES FOR PILOT PROGRAMMING AND TESTING

To evaluate module programming requirements and demonstrate the functional and diagnostic test capabilities of the NARF ATS, a pilot programming effort was initiated for selected avionic modules of the P-3C. Arrangements were made with a NARF to program the selected modules.

After reviewing P-3C system characteristics and engineering data packages, two modules of the AN/ASA-70 were identified by ARINC Research as representative of the complex modules used in the P-3C avionic systems and were selected for pilot programming at the NARF. These modules — the Analog Gate Amplifier and Selection/Deflection Amplifier — contain both digital and analog circuits, require a variety of input stimuli, have a wide range of measurement requirements, a relatively high functional complexity, a large number of discrete parts and integrated circuits, complex waveforms, and are not designated for IMA support.

3.4 RESULTS OF TESTING DEMONSTRATION

Complete functional and diagnostic test programs were developed by NARF Norfolk maintenance personnel and the ATS vendor for the two AN/ASA-70 modules. The programming effort required approximately 400 man-hours for each of these complex modules. A demonstration was held for NASC representatives at NARF Norfolk on 14 January 1970. The functional test (end-to-end testing) was performed in approximately five minutes. The diagnostic test, which demonstrated the ATS's capability to isolate faults to two or three discrete components, was completed in approximately twenty minutes. The diagnostic test also included various potentiometer adjustments.

3.5 RESULTS OF EVALUATION

Table 2 lists the avionic systems peculiar to the P-3C for which there are sufficient data available to permit an evaluation. The table also shows the percentage of modules that appear to be testable on the NARF ATS.

Table 2. **SUMMARY OF MODULE COMPATIBILITY WITH NARF ATS**

System	Number of Module Types	Percentage of Module Types Which can be Tested With Currently Configured NARF ATS	Module Types Requiring Alternate Support Methods
AN/ASQ-114	82	97	Memory and Rope Stack Units designed for commercial repair
AN/ASA-70	35	83	(1) Tube Shield Assemblies (2) designated commercial repair (2) Three module types require High Voltage Building Block (3) One module type requires Synchro capabilities
AN/ASA-64	5	100	
AN/ASA-65	4	75	One module type requires Synchro capabilities
AN/ASA-66	10	100	
AN/ASA-69	45	89	(1) Three module types require High Voltage Building Block (2) Two module types require Synchro capabilities

A report is being prepared that will detail the stimuli, measurement, and the interface requirements for each module of the systems evaluated for compatibility with the Model 5500 ATS.

Approximately eight percent of the modules evaluated cannot be supported with the NARF ATS as it is presently configured. Alternate methods of support will therefore be required. These alternate methods are discussed in Chapter Four.

CHAPTER FOUR

ALTERNATE SUPPORT METHODS

When it is not economically feasible to support a selected item with an ATS or when the item is not testable with the ATS, alternate methods of support must be investigated. As was indicated in Figure 2, some of the methods which were considered are:

- Vendor repair for an indefinite period
- Specially configured NARF test equipment
- Module throwaway
- ATS building blocks
- PGSE and modified PGSE

4.1 INDEFINITE VENDOR REPAIR

Because some of the selected items are very complex, they may require special repair facilities, have a high dollar value, and require the skills of highly trained technicians. It is often desirable to designate such items for commercial repair.

4.2 SPECIALLY CONFIGURED NARF TEST EQUIPMENT

Unique modules may require special tests that cannot be performed with the equipment supporting the prime systems. It may prove more economical, therefore, to construct a special test set for support of these modules at the depot level.

4.3 MODULE THROWAWAY

A repair-versus-throwaway analysis should be conducted to determine whether it is economically feasible to discard defective modules. A study has recently been completed by ARINC Research Corporation which provides a means of making the module-repair-versus-throwaway decision for the P-3C avionic equipments.*

4.4 ATS BUILDING BLOCKS

Synchro, high-voltage, and high-frequency stimuli which are not within the capability of the ATS are often necessary to test selected modules.

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*Special Report No. 6 *Formulation and Application of Repair-Discard Screening for Selected P-3C Avionic Systems*, July 1970, ARINC Research Publication.

As the need arises and cost-effectiveness studies justify the demand, commercially available devices in the form of building blocks could be added to the ATS to expand its testing capability. Preliminary investigations reveal that ten additional P-3C modules of the six systems evaluated could be tested with the addition of synchro and high-voltage building blocks.

4.5 PGSE AND MODIFIED PGSE

PGSE is normally designed for a specific equipment and is assumed to be compatible with that equipment in all respects. However, other factors, such as cost, training, production lead time, personnel requirements, and facilities must be considered.

CHAPTER FIVE

COMPARISON OF PECULIAR GROUND SUPPORT EQUIPMENT AND THE NARF ATS

Peculiar Ground Support Equipment encompasses a multitude of configurations, from TBIs to specially designed equipments which are used to test individual assemblies or modules of specific systems. Listed below are some of the advantages of using PGSE to support new weapons systems when they are introduced into the fleet:

- PGSE is designed to test a particular system
- The test-equipment design and operational characteristics of PGSE are generally optimized to meet the unique requirements of the prime system it supports
- PGSE operates independently of other test stations
- PGSE can be used in the performance of end-to-end tests of a system or assembly
- Use of PGSE permits marriage of assemblies to the system

A general-purpose Automatic Test System provides an integrated test capability that allows a single test set to support modules — or sometimes assemblies — of many different systems. The following are advantages to be realized through use of an ATS:

- The number of test equipments in the Navy inventory is reduced
- The number of personnel is reduced, and required personnel operator training and skill levels may be lowered
- Shop space requirements are reduced
- Testing and test results are standardized
- Overall support equipment costs decrease
- Requirements for new test equipments to support new systems are reduced (new systems require test programs in lieu of test equipment)
- Avionics changes to prime systems require only modifications to test program tapes
- Test capability is increased by the addition of building blocks

Comparisons of these two support methods were somewhat limited since most vendors had not developed recommendations for depot-type support equipment nor had they been required to develop depot-support requirements. Vendors were contacted and efforts were made to obtain estimates of depot support requirements and cost data for use in this comparison. In the absence of this data, systems that are supported by an IMA were assumed to be supportable by the same test equipment at the depot level; therefore, the same requirements and cost data were used for this comparison.

Detailed support requirements and cost data for the NARF ATS were available and were used for the comparison with PGSE.

5.1 HARDWARE/SOFTWARE COST COMPARISON

Initial investment costs for both hardware and software for two depot support methods, PGSE and ATS, were compared for six avionic systems peculiar to the P-3C. Costs considered for this comparison were as follows:

- Recurring and nonrecurring (if applicable) costs of vendor PGSE and required system assemblies
- NARF Automatic Test System, including the following:
  - ATS Multiplex Test Station (the Multiplex Test Station has the same testing capabilities as the NARF ATS Master Test Station and will time-share with the computer of the Master Test Station currently installed at the NARFs)
  - Interface hardware ($200 per module type)
  - Software (based on an average programming time of 175 hours per module type at $17 per hour)
  - High Voltage and Synchro Building Blocks, where applicable

Table 3 lists the cost breakdown for two depots, based on preliminary cost data, for the six systems evaluated.

The NARF ATS, as currently configured, will test approximately 92 percent of the modules of the six systems evaluated. If a High Voltage Building Block is added, approximately 96 percent of the modules in these systems can be tested. The addition of both the High Voltage and Synchro Building Blocks will increase the testing capabilities to approximately 98 percent of the modules in the same systems. The cost of obtaining this added 6 percent capability is $247,000 for two depots. The increased capability would not only provide added support for other P-3C systems, but would increase the potential of supporting other weapon systems.

The ATS Multiplex Test Station and building blocks were included in the total cost comparison. This same equipment would be used to test all P-3C systems supported by the ATS concept.

The overall investment savings realized by using the ATS support concept for these six systems is $729,769.

Determination of the type of depot support equipment should not be based on the cost of support equipment alone. Other factors which must be considered are the following:

- Projected depot workload (equipment loading)
- Space requirements
- Training requirements
- Manpower requirements
- Support equipment spares requirements
- Delays encountered in establishing depot capabilities

Table 3. **SSE AND ATS INITIAL INVESTMENT COSTS COMPARISON**

System	PGSE	Cost (Two Depots)	ATS	Cost (Two Depots)
AN/ASQ-114	Automatic Logic Module Analyzer	$ 315,682	Software	$ 235,025
	Analog Assembly Analyzer Unit	526,679	Interface hardware	32,000*
	Power Supply Test Set	545,000		
	Total	$1,387,361	Total	$ 267,025
AN/ASA-70	Analyzer/Verifier Tester	$ 350,000	Software	$ 98,175
			Interface hardware	13,200*
	Total	$ 350,000	Total	$ 111,375
AN/ASA-64	TBI (includes ASA-64 Assemblies and RO32ASQ10)	$ 12,870	Software	$ 14,875
			Interface hardware	2,000
	Total	$ 12,870	Total	$ 16,875
AN/ASA-65	TBI (includes ASA-65 Assemblies)	$ 21,888	Software	$ 11,900
			Interface hardware	1,600
	Total	$ 21,888	Total	$ 13,500
AN/ASA-66	TBI (includes ASA-66 Assemblies)	$ 114,050	Software	$ 29,750
			Interface hardware	4,000
	Total	$ 114,050	Total	$ 33,750
AN/ASA-69	Radar Scan Converter Test Set	$ 245,000	Software	$ 133,875
			Interface hardware	18,000
	Total	$ 245,000	Total	$ 151,875
			Multiplex Test Stations (2)	$ 560,000
			High Voltage Building Block (2)	20,000
			Synchro Building Block (2)	227,000
	Grand Total	$2,131,169	Grand Total	$1,401,400

*Does not include modules designated for commercial repair

5.2 DEPOT LOADING

The ATS capacity at the NARF is estimated at 300 units per month, assuming an eight-hour shift for each depot. If the depot induction rates presented in Appendix A are applied, the depot loading for the six systems evaluated will require only 34 percent of the total capacity of both depot ATSs when 130 aircraft are operating in the fleet. The remaining 66 percent of the ATS capacity could be used to support other P-3C avionic systems, other aircraft weapons systems, or to perform required maintenance for the ATS.

The testing capacity for PGSE varies with the type of support equipment and the type of units supported. Automatic PGSE would require approximately the same testing time as the NARF ATS, and would, therefore, have the same workload capacity. PGSE requiring manual operation and troubleshooting is estimated to be more time-consuming by a factor of at least 6:1,* resulting in a reduced workload capacity. After reviewing the induction rates for the systems evaluated and their individual PGSE capacity, ARINC Research estimates that the depot loading would be within the capacity of a single unit of the applicable PGSE at each of the two depots.

5.3 SPACE AND TRAINING REQUIREMENTS

5.3.1 Space Requirements

With the introduction of new aircraft into the fleet, more sophisticated and complex weapons systems are added to the Navy inventory. These additional weapons systems are compounding the space problems experienced by most NARFs. Table 4 lists the estimated shop space requirements for both PGSE and ATS to support six systems at the depot level.

Table 4. SHOP SPACE REQUIREMENTS

System	Space Required for PGSE (square feet)	ATS	Space Required (square feet)
AN/ASQ-114	78	Multiplex Test Station	220
AN/ASA-70	52	Peripheral Storage	60
AN/ASA-64	26		
AN/ASA-65	52		
AN/ASA-66	39		
AN/ASA-69	52		
Total	299		280

A Pragmatic Approach to Successful ATE, by C. M. Barrack, AAI Corporation

The ATS will require 280 square feet of shop space until its maximum loading capacity is reached. The total space requirements for PGSE will increase as depot capabilities are developed for each new system.

The estimated space requirements for supporting the 30 P-3C-peculiar avionic systems by either PGSE or ATS are shown below:

- Estimated PGSE space requirement, 1700 square feet
- ATS space requirement, 280 square feet

The PGSE shop space estimates were based upon known depot space requirements when such information was available. Otherwise IMA space requirements were used. If no data were available, it was assumed that a 26-square-foot area would be required for the PGSE for each system. This is the amount of space required for a standard electronic workbench and personnel area. The figure was applied to PGSE space requirements for 12 of the 30 P-3C-peculiar avionic systems.

5.3.2 Training Requirements

Systems supported at the depot level by PGSE will normally require separate test stations for each prime system. This necessitates separate maintenance training courses for each prime system and PGSE. Considerable savings in training costs and man-hours can be realized by using a single ATS capable of supporting modules of many different systems. The savings will increase as the number of systems supported by the ATS increases, since only one training course will be required and there will be little or no increase in personnel requirements.

There is no formal depot training requirement established at this time for PGSE for the P-3C. Therefore, it is impractical to estimate the savings which could be realized by using an ATS in place of PGSE.

5.3.3 Manpower Requirements

Normally, operator/maintenance personnel are required for each PGSE test station that supports a prime system. It is conceivable that systems which have a fairly low depot workload, and are supported by PGSE, could be grouped together, thus requiring only one operator to support them. For the six systems evaluated, 4 to 6 persons would be required to operate and maintain the PGSE.

An ATS requires at least one, or possibly two, operators to support a group of systems. Therefore, use of an ATS to support the six systems evaluated in this study would result in a reduction of from 50 to 83 percent in manpower requirements.

5.4 GENERAL

As new weapons systems are introduced into the Navy inventory, new support equipment must be developed, or existing support equipment must be extensively modified. The ATS is versatile enough to support new avionics systems with the simple addition of new program tapes, or, if deemed necessary, the addition of building blocks rather than new specialized test equipment.

Workload saturation at a particular depot may be relieved by supplying the necessary program tapes and interface accessories to another less heavily taxed Navy depot.

The testing capacity of a depot can be expanded by the addition of up to three Multiplexed Test Stations which time share with the general-purpose computer of the Master Test Station on a noninterfering basis.

Appendix B contains a list of the 30 P-3C avionic systems that were studied, a limited comparison of PGSE and ATS cost (based upon available data), and the type of depot support for these systems that was recommended by ARINC Research Corporation to the P-3C Transition Planning Conference Support Equipment Subcommittee which met 19 to 21 January 1970. The same recommendations were submitted at the P-3C Avionics Systems Depot Maintenance Meeting of 5 March 1970. The recommendations, except for those applicable to the AN/AQA-7 and AN/ASA-66, were accepted.

As a result of these meetings, it was determined that serious delays could result in establishing depot capabilities within a reasonable time because of the magnitude of the ATS programming effort. Consequently, some systems are recommended for support by the same PGSE used at the IMA, although the NARF ATS could be used to support these systems at the depot level.

CHAPTER SIX

IMPLEMENTATION OF DEPOT SUPPORT

A priority listing and milestone schedule should be established for implementing depot support for P-3C avionic systems. This chapter describes some of the requirements for such implementation. In addition to the timely procurement of the appropriate quantity and type of support equipment, the following must be provided:

- Facility space
- Trained personnel
- Spares and repair parts
- Technical data

6.1 NARF FACILITIES

Two NARFs, located at NAS Norfolk, Virginia, and at NAS Alameda, California, are the Designated Overhaul Points (DOP) for the P-3C aircraft. Additional facilities are currently under construction at both DOPs and should be completed in time to provide the required space for support of the P-3C systems.

"Clean rooms" are required for aligning the platform, sealing, repairing the accelerometer, and overhauling the gyro of the Inertial Navigation System (INS). Ample space for INS testing and repair is available at NARF, Norfolk. Sufficient clean room facilities are not available at NARF, Alameda, but do exist at the North Island facility.

6.2 PERSONNEL

Maintenance personnel requirements for P-3C avionic support must be weighed against the available manpower at the NARF. Maintenance personnel for PGSE must be specially trained prior to installation of the test equipment.

Maintenance personnel have received eight weeks of training on the NARF ATS, including three weeks of programming training. Limited programming capabilities are now available at both NARFs.

6.3 SPARES AND REPAIR PARTS

Meeting the required Turn-Around Time (TAT) at the depot level depends not only upon the NARF capabilities but the availability of spares and repair parts. A quantity of spare and repair parts, which should be sufficient to satisfy the projected workload demands, has been procured for depot support. These items are currently being used for commercial overhaul but will be available to the NARFs when in-house capability is established.

6.4 TECHNICAL DATA REQUIREMENTS

Technical data must be compatible with the prime equipment and the method of depot support. Overhaul manuals compiled from an Engineering Data Package are normally used by the depot to test and repair avionic modules. These manuals are usually tailored to the method of depot support (PGSE, ATS, etc.). Since the test equipment for depot support has not been defined, overhaul manuals have not yet been procured.

6.4.1 PGSE Technical Data

Depot overhaul manuals will be required for systems supported at the depot by PGSE. The technical data requirements and format of these manuals should be in accordance with existing military specifications.

6.4.2 ATS Technical Data

6.4.2.1 Programming Data Package

Systems supported by an ATS will require manuals of a different format than those required for systems supported by PGSE. The manual to be used with the ATS will hereafter be referred to as the Programming Data Package. The Programming Data Package is generated during the process of software development and will follow the general format listed below:

1. Cover sheet
2. Title page
3. ATS minimum-performance standard
4. Test cover sheet
5. Functional block diagram
6. Layout schematic
7. Types of adapter connector
8. Types of special adapter
9. Parts list
10. Test flow diagram
11. Program instruction printout
12. Test printout (machine language)
13. Test printout
14. Appendix A (manufacturer's test specifications)
15. Program soft copy

ATS software development requires a qualified programmer to have at his disposal an engineering data package as defined in Section 3.1.

An engineering data package, containing sufficient data for developing ATS software, has been procured for each GFE system peculiar to the P-3C. Engineering data packages will be required for CFE systems that are to be supported by the ATS. These data packages should be procured at the earliest possible date because of the lead time required to compile the engineering data package and develop ATS software.

6.4.2.2 ATS Software Development

Software development has been recognized as one of the major contributors to the high cost of the ATS. The test-oriented machine language used with the NARF ATS permits programming by technician-level personnel, thus reducing software costs. The following steps are required in programming a module for automatic testing:

- Preliminary review of module data
- Program test design
- Interface design and fabrication
- Manual validation of the test program
- Machine coding
- Automatic validation
- Production testing

6.4.2.2.1 Module Evaluation

Module data is analyzed to determine the compatibility of the module and the ATS. The module characteristics and test specifications are compared with the stimuli and measurement capabilities of the ATS. Special coupling components, loads, test circuits, and connectors required to interface the Unit Under Test (UUT) are identified.

6.4.2.2.2 Program Test Design

A test flow chart which identifies the step by step diagnostic test procedure is prepared by the programmer. The depth of fault isolation, either by automatic testing or limited manual probing, will be identified. The programmer will also prepare a diagram illustrating patch-card wiring, measurement-point assignment, and UUT adapter cable wiring.

6.4.2.2.3 Validation

Manual controls of stimuli, measurement, and switching functions permit the programmer to manually validate each step in the diagnostic flow chart prior to translating the actual test program into machine language. After manual validation, the program is transcribed into a complete test-oriented language for automatic validation. Automatic validation assures that the program has been properly transcribed and that the same test limits that were manually validated will still be valid during high-speed testing.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The following conclusions were reached by ARINC Research regarding depot support of the avionic systems peculiar to the P-3C. Many factors should be considered before selecting depot support equipment, including the following:

- Support equipment cost
- Support equipment capacity
- Space requirements
- Training requirements
- Manpower requirements
- Spares requirements
- Support equipment availability

The following additional conclusions have been reached:

- Most equipment vendors have not developed depot-type support equipment
- Some PGSE at IMAs could be used for depot support
- The success of pilot programming and testing of the AN/ASA-70 modules indicates that the ATS in use at NARFs can be effectively applied to P-3C depot maintenance. Emphasis on the success of this programming and test effort is not intended to imply that all avionic modules of the P-3C can be tested successfully with the ATS.
- The NARF ATS was considered a logical candidate for depot support of selected P-3C-peculiar avionic systems
- Systems which permit only assembly replacement as a corrective maintenance action are not amenable to ATS support
- Analysis of available engineering data packages reveals that some modules are not compatible with the NARF ATS.
- Data packages are not available for CFE avionic systems.
- Building blocks can increase the capability of an ATS
- Initial investment savings of approximately 30 percent can be realized by using the NARF ATS for the six systems investigated.
- Considerable savings can be realized in space, training, and manpower requirements by using depot ATS support.
- Workload capacity can be increased by obtaining support from other NARFs equipped with an ATS.

7.2 RECOMMENDATIONS

As a result of this study, and based upon an analysis of the data contained in Appendix B, ARINC Research Corporation recommends the following:

- That depot-support equipment be definitized for each P-3C-peculiar avionic system using Table 5 as a guide:
- That Navy depot support be established at the earliest possible date for the P-3C-peculiar avionic systems
- That a Multiplex Test Station, equipped with a High Voltage and Synchro Building Block, be purchased for support of selected P-3C systems at each P-3C DOP.
- That Engineering Data Packages or required overhaul manuals be purchased for all applicable P-3C systems.
- That a priority list and milestone schedule be established for implementing depot support and developing ATS test programs.
- That an analysis be conducted to identify modules which can be discarded.

ARINC Research also recommends a continuing analysis, as data packages become available, on the remaining systems to identify additional modules that are compatible with the NARF ATS.

Table 5. **DEPOT-SUPPORT EQUIPMENT REQUIRED TO SUPPORT P-3C SYSTEMS**

System	Depot-Support Equipment
AN/ACQ-5	NARF ATS
AN/AGC-6	NARF ATS and PGSE
AN/AJN-15	NARF ATS
AM-4923	NARF ATS
AN/APN-187	PGSE
AN/APS-115	PGSE + vendor
AN/AQA-7	NARF ATS
AN/AQH-4	PGSE
AN/ARC-142	PGSE
AN/ARC-143	PGSE
AN/ARR-72	NARF ATS
AN/ASA-64	~~NARF ATS~~ PGSE
AN/ASA-65	NARF ATS PGSE
AN/ASA-66	NARF ATS PGSE
AN/ASA-69	NARF ATS
AN/ASA-70	NARF ATS and vendor repair
AN/ASN-84	NARF ATS and PGSE
AN/ASQ-114	NARF ATS and vendor repair
AN/AXR-13	PGSE
AN/AYA-8	NARF ATS
ID-1540/A	PGSE
TD-900/AS	NARF ATS
51V4	PGSE Have present capability
AN/ALQ-78	PGSE
AN/ASQ-81	NARF ATS and vendor repair
AN/ASW-31	PGSE
RO-308/SSQ	PGSE
CV-2461/A	NARF ATS
AN/ARA-50	PGSE } available to
R-1651	PGSE } transition

per 5 signs

APPENDIX A

PROJECTED DEPOT WORKLOAD

The depot capacity required for support of the P-3C-peculiar avionic systems can be estimated with reasonable accuracy, if the projected workload is known. ARINC Research assumed the task of calculating the projected depot workload or induction rate (IR) for each module type. This was accomplished by utilizing the following formula:

$$IR = (fr \cdot \Theta \cdot N) \cdot H$$

where:

fr = depot failure rate (failures which require depot repair)

Θ = theta factor (compensates for false removals, ground operate time, in-flight utilization, and growth factor)

N = quantity (modules or units) per aircraft

H = flying hours per period

The depot failure rates were taken from the annotated PPBs (Privisioning Parts Breakdown) used at the provisioning conferences.

Since most of the P-3C systems analyzed did not use an IMA, the depot induction rate was higher than would normally be expected for this type equipment.

Table A—1 is a projection of the depot induction rate per month when 42 or 130 fleet aircraft, respectively, are considered (based on a 92 flying hours per aircraft per month).

Table A—1. **DEPOT INDUCTION RATE**

System	Module Depot Induction (Rate per Month)*		Total Depot Induction (Rate per Month)	
	42 Aircraft	130 Aircraft	42 Aircraft	130 Aircraft
AN/ASA-70	49.4	153.1	55.8	172.9
AN/ASQ-114	134.4	418.1	136.0	421.6
AN/AYA-8	109.7	340.0	112.1	347.5
AN/ASA-69	7.1	22.0	7.1	22.0
CV-2461/A	29.1	90.2	29.1	90.2
AN/AQA-7	79.9	247.6	79.9	247.6
AN/APN-187	9.7	30.0	12.5	38.7
AN/ARC-142	10.7	33.1	11.1	34.4
AN/ARC-143	11.8	36.5	13.8	42.7
AN/ACQ-5	16.7	51.7	16.7	51.7
AN/APS-115	5.7	17.6	15.3	47.4
AN/ASN-84	55.9	173.3	88.8	275.2
AN/ARR-72	21.4	66.3	21.6	66.9
AN/AGC-6	2.8	8.6	2.8	8.6
AN/ARA-50	—	—	**	**
AN/AJN-15	9.1	28.2	9.1	28.2
AM-4923	3.3	10.2	3.3	10.2
AN/AQH-4	5.0	15.5	5.0	15.5
AN/ASA-64	2.5	8.3	2.5	8.3
AN/ASA-65	1.7	5.2	1.7	5.2
AN/ASA-66	2.5	8.3	2.5	8.3
AN/AXR-13	0.3	0.9	0.3	0.9
RO308/SSQ	1.4	4.3	1.4	4.3
ID-1540	—	—	2.8	8.6
TD-900	7.0	21.7	7.0	21.7
51V4	—	—	7.0	21.7
AN/ALQ-78	43.2	133.9	52.3	162.1
AN/ASQ-81	8.1	25.1	13.9	43.0
AN/ASW-31	21.1	65.4	21.1	65.4
R-1651	—	—	**	**
Total	649.5	2015.1	732.5	2270.8

*Does not include items designated "commercial repair for life" or "black boxes".
**Insufficient Data

APPENDIX B

COMPARISON OF DEPOT SUPPORT CONCEPTS

Table B—1 contains a listing of the thirty P-3C-peculiar avionic systems, gives a limited comparison of initial investment costs which would be incurred in implementing the two types of depot support (PGSE or ATS), and provides a listing of the primary type of depot support equipment as recommended by ARINC Research Corporation. Cost data for PGSE was extremely limited or nonexistent in many instances, therefore, the total cost of PGSE for various systems is unknown.

Test Bench Installations (TBI), as the term is used in this appendix, comprises a "hot bench", Test Bench Harness (TBH) and system assemblies, and the necessary PGSE required for depot maintenance.

The programming priority of systems supported by the ATS-concept should be based on the following:

- Availability of IMA support (systems without IMA support should receive high priority)
- Availability of commercial repair facilities (systems which will require additional vendor facilities, support equipment, or personnel for commercial repair should receive high priority)
- Availability of engineering data package

Table B—1. (continued)

System	IMA Support	Peculiar Ground Support Equipment (PGSE)	PGSE Cost (Two Depots)	NARF Automatic Test System (ATS)	ATS Cost (Two Depots)	Remarks	Primary Support Equipment *Recommended for* Depot Support
AN/ASA-66 (GFE)	Yes	TBI *a. TBII and Accessory Kit* b. Holding Fixture, CRT c. System Signal Generator d. ASA-66 Assemblies Total	 $ 4,920 530 70,000 38,600 $114,050	Software *Interface hardware* Total	$ 29,750 4,000 $ 33,750	1. All modules compatible with NARF ATS 2. *NASC anticipates complete assemblies will be returned to the NARF for test and repair, thus establishing a requirement for PGSE*	NARF ATS
AN/ASA-69 (GFE)	No	Radar Scan Converter Test Set Total	$245,000 $245,000	Software Interface hardware *Total*	$133,875 18,000 $151,875	1. *All modules compatible with NARF ATS*	NARF ATS
AN/ASA-70 (GFE)	No	*Analyzer/Verifier Tester* Total	$350,000 $350,000	Software Interface hardware Total	$ 98,175 13,200 $111,375	1. 94 percent of modules compatible with NARF ATS 2. Two tube-shield assemblies are designated for commercial overhaul	NARF ATS and vendor repair
AN/ASN-84 (CFE)	Yes	IMU Test Consoles* Accessory Equipment Two Sets INS Module Testers Total	$1,650,000 1,000,000 922,000 $3,572,000	Software Interface hardware Total	$121,975 16,400 $138,375	1. Approximately 90 to 95 percent of modules are estimated to be compatible with NARF ATS 2. *Replaceable assemblies (IMU) must be tested* and aligned on PGSE 3. *Engineering data package required for detailed evaluation*	NARF ATS and PGSE
AN/ASQ-114 (GFE)	No	Automatic Logic Module Analyzer Analog Assembly Analyzer Unit Power Supply Test Set Total	$ 315,682 526,679 545,000 $1,387,361	Software Interface hardware Total	$235,025 32,000 $267,025	1. 98 percent of modules compatible with NARF ATS 2. Memory and rope stack modules are designated for commercial repair	NARF ATS and vendor repair
AN/AXR-13 (GFE)	Yes	TBI a. TBII b. TV Monitor c. Collimator Test Set d. Test Set, Camera e. Accessory Equipment f. AXR-13 Assemblies Total	 $180,000 109,682 $289,682	Software Interface hardware Total	$ 53,550 7,200 $ 60,750	1. *Replaceable assemblies must be tested with* PGSE	PGSE
AN/AYA-8 (GFE)	No	TBI (RD-319 MTT only) RD-319 Assembly	Unknown $139,200	Software Interface hardware Total	$261,800 35,000 $296,800	1. All modules are thought to be compatible with NARF ATS 2. *Further evaluation required to determine if TBI* is required at depot level to support Magnetic Tape Transport (MTT). IMA could provide support of MTT to the module level since it has TBI	NARF ATS
ID-1540/A (CFE)	No	TBI a. Test Console b. Meter Movement Test Set c. Range Counter Test Set	 Unknown Unknown Unknown			ATS support not applicable	PGSE
ID-900/AS (CFE)	No			Software Interface hardware *Total*	$ 14,885 2,000 $ 16,885	1. *All modules are thought to be compatible with* NARF ATS 2. Engineering data package required for detailed evaluation	NARF ATS
51V-1 (CFE)	Yes	TBII-B571 Total	$ 970 $ 970			NAREs have capability	PGSE
AN/ALQ-78 (CFE)	No	TBI *a. TBII* b. ALQ-78 Assemblies	 *Unknown* $230,610	Software *Interface hardware* Total	$214,200 28,800 $243,000	1. Approximately 88 percent of modules are estimated to be compatible with NARF ATS 2. RF section and antenna must be tested with PGSE 3. Modules could be supported by ATS with vendor repair for RF section and antenna 4. *Engineering data package required* for detailed evaluation	PGSE
AN/ASQ-81 (GFE)	No	TBI a. *TBII* b. ASQ-81 Assemblies	 *Unknown* $105,220	Software Interface hardware Total	$ 44,625 6,000 $ 50,625	1. Approximately 95 percent of modules are estimated to be compatible with NARF ATS 2. Magnetic Detector designated for commercial repair 3. Engineering data package required for detailed evaluation	NARF ATS and vendor repair
AN/ASW-31 (CFE)	Yes	Lear-UACT Tester Total	$ 81,200 $ 81,200	Software Interface hardware Total	$101,150 13,600 $111,750	1. Engineering data package required for detailed evaluation	PGSE
RO-308/SSQ (GFE)	Yes	TBI a. *TBII* b. RO-308 Recorder Assembly	 Unknown $ 12,231	Software Interface hardware Total	$ 5,950 800 $ 6,750	1. Similar equipments are currently supported at NAREs with PGSE	PGSE
CV-2461/A (GFE)	No			Software Interface hardware Total	$119,000 16,000 $135,000	1. Approximately 95 to 100 percent of modules are estimated to be compatible with NARF ATS	NARF ATS
AN/ARA-50	Yes	NAREs currently have capability				*NARF will require increased capacity to support* this system with existing capabilities	PGSE
R-1651	Yes	NAREs currently have capability				NARF will require increased capacity to support this system with existing capabilities	PGSE

*Workload and testing time requires at least six IMU Test Consoles

Table B—1. COMPARISON OF DEPOT SUPPORT CONCEPTS

System	IMA Support	Peculiar Ground Support Equipment (PGSE)	PGSE Cost (Two Depots)	NARF Automatic Test System (ATS)	ATS Cost (Two Depots)	Remarks	Primary Support Equipment Recommended for Depot Support
AN/ACQ-5 (CFE)	No			Software Interface hardware Total	$478,975 64,400 $543,375	1. Approximately 93 percent of modules are estimated to be compatible with NARF ATS 2. Engineering Data Package required for detailed evaluation	NARF ATS
AN/AGC-6 (CFE)	No	TBI a. Thermal Print Head Tester b. Thermal Print Head Jig c. Test Harness d. Word Code Generator e. AGC-6 Assemblies	 Unknown Unknown Unknown Unknown $ 63,140	Software Interface hardware Total	$ 86,275 11,600 $ 97,875	1. Approximately 90 percent of modules are estimated to be compatible with NARF ATS 2. Engineering data package required for detailed evaluation 3. Mechanical assemblies require PGSE	1. NARF ATS and PGSE 2. Final recommendation delayed pending evaluation by cognizant AIR-04 engineer
AN/AJN-15 (CFE)	No			Software Interface hardware Total	$ 26,775 3,600 $ 30,375	1. All modules thought to be compatible with NARF ATS 2. Engineering data package required for detailed evaluation	NARF ATS
AM-4923 (CFE)	No			Software Interface hardware Total	$ 8,925 1,200 $ 10,125	1. Not economically feasible to repair all modules 2. Selected modules coded consumable 3. Engineering data package required for detailed evaluation	NARF ATS
AN/APN-187 (CFE)	Yes	TBI a. TBH, Doppler b. Test Set, Antenna c. Frequency Tracker and Altimeter Test Set d. SPA-100A Spectrum Analyzer e. GPL-1 Spectrum Analyzer f. AN/APN-187 Assemblies Total	 $ 10,200 33,000 89,600 12,012 17,000 132,788 $294,600	Software Interface hardware Total	$ 83,300 11,200 $ 94,500	1. PGSE is required to test microwave assemblies, antenna, and modules which must be aligned as matched sets. 2. Engineering data package required for detailed evaluation	PGSE
AN/APS-115 (CFE)	Yes	TBI a. TBH, Radar b. Mount, Antenna c. AN/APS-115 Assemblies Total	 $ 64,200 12,572 211,766 $288,538	Software Interface hardware Total	$136,850 18,400 $155,250	1. Assemblies and microwave modules must be tested on PGSE 2. Engineering data package required for detailed evaluation	PGSE
AN/AQA-7 (GFE)	Yes	TBI a. TBH and Accessories b. AN/AQA-7 Assemblies Total	 $287,958 436,882 $724,840	Software Interface hardware Total	$202,300 27,200 $229,500	1. Approximately 90 to 93 percent of modules are estimated to compatible with NARF ATS 2. PGSE may be required for testing replaceable assemblies 3. AN/AQA-7 is scheduled for reprovisioning in the near future, and maintenance concept could change	NARF ATS
AN/AQH-4 (CFE)	Yes	Kit, Maintenance (includes TBH) AN/AQH-4 Assemblies	$ 9,400 Unknown	Software Interface hardware Total	$ 14,875 2,000 $ 16,875	1. Engineering data package required for detailed evaluation	PGSE
AN/ARC-142 (CFE)	Yes	TBI a. TBH b. Indicator, PANALZOR c. AN/ARC-142 Assemblies Total	 $ 84,000 5,600 180,122 $269,722	Software Interface hardware Total	$178,500 24,000 $202,500	1. Approximately 95 percent of modules are estimated to be compatible with NARF ATS 2. Engineering data package required for detailed evaluation 3. AN/ARC-142 TBI required for testing Antenna Coupler CU-1809	PGSE
AN/ARC-143 (CFE)	Yes	TBI a. TBH b. Coupler, Coax c. Termination d. Calorimeter e. 608F Generator, UHF Signal f. 8708A Synchronizer g. AN/ARC-143 Assemblies Total	 $ 74,000 700 200 4,400 4,324 4,716 135,924 $224,264	Software Interface hardware Total	$ 62,475 8,400 $ 70,875	1. Approximately 90 percent of modules are estimated to be compatible with NARF ATS 2. Engineering data package required for detailed evaluation 3. RF units must be tested with PGSE	PGSE
AN/ARR-72 (CFE)	Yes*	TBI (ASSG) SG-791/ARR-72 (ASSG)	Unknown $ 22,800	Software Interface hardware Total	$ 74,875 10,000 $ 84,875	1. Approximately 95 percent of modules are estimated to be compatible with NARF ATS 2. Engineering data package required for detailed evaluation	NARF ATS
AN/ASA-64 (GFE)	Yes	TBI a. TBH b. AN/ASA-64 Assemblies (includes RO32ASQ10) Total	 $ 2,510 10,360 $ 12,870	Software Interface hardware Total	$ 14,875 2,000 $ 16,875	1. All modules compatible with NARF ATS	NARF ATS
AN/ASA-65 (GFE)	Yes	TBI a. TBH b. ASA-65 Assemblies Total	 $ 8,888 13,000 $ 21,888	Software Interface hardware Total	$ 11,900 1,600 $ 13,500	1. All modules compatible with NARF ATS	NARF ATS

*AN/ARR-72 ASSG Assembly only

(continued)